STATE OF CALIFORNIA
Budget Change Proposal - Cover Sheet
DF-46 (REV 08/15)

Fiscal Year	Business Unit	Department	Priority No.
2016-17	0690	Office of Emergency Services	MR 2

Budget Request Name	Program	Subprogram
0690-401-BCP-DP-2016-MR	**0385**	

Budget Request Description
California Earthquake Early Warning System and Program

Budget Request Summary
The California Governor's Office of Emergency Services requests 4.0 permanent positions and $10 million General Fund state operations in State Fiscal Year 2016-17. This is to provide initial operating costs and staff to build out the California Earthquake Early Warning System and Program.

Requires Legislation	Code Section(s) to be Added/Amended/Repealed
☐ Yes ☒ No	

Does this BCP contain information technology (IT) components? ☐ Yes ☒ No *If yes, departmental Chief Information Officer must sign.*	Department CIO	Date

For IT requests, specify the date a Special Project Report (SPR) or Feasibility Study Report (FSR) was approved by the Department of Technology, or previously by the Department of Finance.
☐ FSR ☐ SPR Project No. Date:

If proposal affects another department, does other department concur with proposal? ☐ Yes ☐ No
Attach comments of affected department, signed and dated by the department director or designee.

Prepared By	Date	Reviewed By	Date
Sara Stillwell	5/7/16		
Department Director Nancy Ward for Mark Ghilarducci	Date 5/10/16	Agency Secretary	Date

Department of Finance Use Only

Additional Review: ☐ Capital Outlay ☐ ITCU ☐ FSCU ☐ OSAE ☐ CALSTARS ☐ Dept. of Technology

BCP Type: ☐ Policy ☐ Workload Budget per Government Code 13308.05

PPBA	Date submitted to the Legislature
	May 13, 2016

A. Budget Request Summary

The California Governor's Office of Emergency Services (Cal OES) requests 4.0 permanent positions and $10 million General Fund state operations in State Fiscal Year (SFY) 2016-17. This is to provide initial operating costs and staff to build out the California Earthquake Early Warning System and Program.

Requested funding will assist with the initial capital and operating costs associated governance of the implementation of the California Earthquake Early Warning System and Program by building upon the state's existing seismic network and proposed implementation strategy to provide a comprehensive and reliable earthquake early warning system statewide. Funds will be used to develop further funding strategies to leverage and recoup future and ongoing costs; for required research to ensure for the leverage of necessary technology and other required technical aspects that will integrate critical public and private infrastructure; and to further develop and launch a comprehensive statewide public education and training capability for earthquake early warning. Finally, funding will provide for the initial necessary staff to implement areas of the System and Program and provide support for aspects of the system's implementation and governance structure.

	Per Year
Capital Costs	$ 6,875,000
Seismic Stations	
GPS Equipment	
Telemetry	
Microwave Nodes	
Recurring Costs	
Public Education and Training	$ 2,241,000
Financial Strategy	$ 150,000
Cal OES Staffing	$ 734,000
Total	**$10,000,000**

Cal OES proposes four (4) positions as follows:
2 Research Program Specialist (RPS) II – oversee the Operations and Education/Training program areas, respectively
1 Associate Governmental Program Analyst (AGPA) – oversee the Research and Development program area
1 Program Manager (PM) II – manage the CA Earthquake Early Warning System and Program and Executive Officer to governing body, once established

B. Background/History

Government Code Section 8585 states that Cal OES is responsible for the state's emergency and disaster response services for natural, technological or manmade disasters and emergency, including activities necessary to prevent, respond to, recover from and mitigate the effects of emergencies and disasters related to people and property.

Government Code Section 8587.8 states that the Cal OES will, in collaboration with the California Institute of Technology (Caltech), the California Geological Survey (CGS), the University of California, the United States Geological Survey (USGS), the Alfred E. Alquist Seismic Safety Commission (CSSC), and other stakeholders, develop a comprehensive statewide earthquake early warning system in California through a public private partnership.

Government Code Section 8587.9 establishes the California Earthquake Safety Fund. Upon appropriation by the Legislature, the moneys in the fund shall be used for seismic safety and earthquake-related programs, including the statewide earthquake early warning system described in Section 8587.8.

Advances in scientific understanding of earthquakes and technological developments have resulted in the capacity to rapidly analyze earthquakes and provide products that are vital to emergency

management and public safety. One such advancement is the capability to provide early warning of an earthquake a few to several seconds prior to the actual arrival of destructive ground motions from a large and damaging seismic event.

These few seconds can enable protective/mitigation actions such as:

- People can drop, cover, and hold on under protective cover, offering reductions from injury or lifesaving opportunities, including school children and our colleges/universities.
- Vehicles can safely slow or stop moving.
- The various critical infrastructure sectors of our state can automatically suspend or stop lifelines minimizing the damage from ground shaking and reducing interruptions in power, gas or telecommunications.
- Workers can move to a safe location, automated systems can ensure elevators doors open, production lines may be shut down and sensitive equipment placed in a safe mode.
- Surgeons, dentists, and other medical facilities can stop or suspend delicate procedures.
- Fire departments can have their firehouse doors opened automatically before they are damaged.
- Energy infrastructure can protect stations and grid facilities from strong shaking.
- High speed, transit, freight and passenger rail can be automatically slowed or stopped.

At present, the California Integrated Seismic Network (CISN) provides post seismic information products that include time, location and magnitude of all earthquakes in California in a time frame of 30 to 90 seconds once shaking has started. Ground motion factors are automatically analyzed to produce a ground shaking intensity map (ShakeMap) within a few minutes after the occurrence of an earthquake. Cal OES currently invests in the maintenance and operation of CISN as detailed below, in partnership with other agencies. Earthquake early warning technology will be deployed building on this existing network as a backbone, as well as the CISN's Earthquake Early Warning prototype system, ShakeAlert.

This effort will repurpose the existing CISN network, and working in a public / private collaboration, will build out the CISN to have the capability for assessing earthquake energy prior to the arrival of shaking and allowing for an immediate warning to the public and to critical infrastructure.

Resource History
(Dollars in thousands)

Program Budget	PY - 4	PY - 3	PY - 2	PY - 1	PY
Authorized Expenditures	2,218	1,806	1,799	1,833	1,845
Actual Expenditures	2,218	1,806	1,799	1,833	1,845
Revenues	0	0	0	0	0
Authorized Positions	2.0	2.0	2.0	2.0	2.0
Filled Positions	2.0	2.0	2.0	2.0	2.0
Vacancies	0	0	0	0	0

C. State Level Considerations

Cal OES is responsible for the coordination of overall state response to major disasters in support of local government. Cal OES is responsible for assuring the state's readiness to respond to and recover from all hazards – natural, human-made, and war-caused emergencies – and for assisting local governments in emergency preparedness, response, recovery, and hazard mitigation efforts.

Cal OES' Earthquake and Tsunami program is responsible for efforts to reduce earthquake risks; tsunami planning, preparedness and hazard mitigation; and promoting volcanic awareness, planning and preparedness in vulnerable areas of California.

Though earthquake early warning involves multiple levels of government as well as the private sector, Cal OES' unique capacity to coordinate and organize response and readiness for emergencies

amongst all stakeholders uniquely positions it to lead this program. State statute requires that Cal OES develop and implement this system and program in California.

D. Justification

Implementation of this System and Program is a complex venture involving both governance and operational components. Like other emergency warning systems, this will impact and in many cases protect essentially every sector in the state, public and private, against damaging earthquakes--and by extension the national and worldwide interests that are dependent on operations that occur in California.

To augment the existing sensor network to deliver reliable early warnings, over 1,000 additional and upgraded field sensors will be required to measure ground motion. Telemetry used to convey data from field sensors to central processers will need to be improved. Central processing centers will need to be built or upgraded to manage the new data streams received from the field sensors. Public notification pathways will need to be expanded or established via internet, public alerting systems, wireless telecommunications devices and other proprietary systems.

As the operational components come on line, concurrently, it will also be critical to raise the awareness and knowledge of the Earthquake Early Warning system through a comprehensive public education and training program. Programmatic staff are required to facilitate and coordinate the implementation of this effort, and to support the overall System and Program governance structure, once established, specifically in these key program functional areas:

- Operations and Technology
- Research and Development
- Finance and Investment
  Public Education and Training

Cal OES staffing for Earthquake Early Warning System and Program support is detailed as follows:

Program Manager II:

Responsible for day-to-day management of the California Earthquake Early Warning System and Program, and as the Executive Officer or the governing body, once established. The PM II will direct staff in developing and implementing their work programs; review work; evaluate performance; ensure compliance with departmental policies, and ensure staff has resources necessary to perform their assignments. Management actions also include development and implementation of work plans, overall and annual funding allocations, review and performance assessment of individual institutions and the overall program, and the preparation of performance reports to the Director and the Legislature. The Program Manager will provide oversight and management of all contracts related to the CISN and California Earthquake Early Warning System and Program.

In the Executive Officer role the PM II will be responsible for ensuring that the governing body meets its programmatic goals. This includes providing technical and planning assistance to the governing body, Cal OES, other state agencies, and other board members on all aspects of the System and Program, including status of implementation, current and future needs.

Research Program Specialist II (2 positions):

The RPS II will participate in, and as necessary take responsibility for, research applications for the operational and education/training work areas. This includes program evaluation research, needs assessments, cost benefit analyses, field investigations and other research that promotes technology development and transfer. Examples of the types of investigations that the RPS II may undertake include human response to warnings and hazard information; field reconnaissance to investigate earthquake early warning impacts on significant earthquakes and tsunamis around the world that may provide insights or lessons learned for California; field survey and inventory of high risk areas; focused interviews or survey research to identify and assess the needs of user groups and assess the impact of programs carried out by the California Earthquake Early Warning System and Program; evaluation studies to assess the effectiveness or cost-benefit of programs; and design pilot projects with user

organizations to test new earthquake early warning technologies and applications. The RPS II positions will also be responsible for development, maintenance, and progress reporting on all contracts related to their program areas.

One RPS II will be assigned to the Operations function and the other RPS II will be assigned to the Public Education and Training function.

Associate Governmental Program Analyst:

Serves as lead for administrative management for Research and Development. The AGPA will monitor, analyze and request work products from participating agencies which include, but are not limited to program staff, the California Seismic Safety Commission, the University of California, the California State University, and other scientific and academic institutions within and outside California. The AGPA will also identify research gaps, develop and track the program's strategic plan and performance measures and organize information to be presented to board members. The AGPA will be responsible for administrative functions related to all contracts developed and overseen by the program.

E. Outcomes and Accountability

Projected Outcomes

Workload Measure	CY	BY	BY+1	BY+2	BY+3	BY+4
Establish Earthquake Early Warning Governance	X					
Complete Earthquake Early Warning Benefits Analysis	X					
Finalize Earthquake Early Warning System Build Out Schedule	X					
Convene governing body and working groups for Operations, Research/Development, Education/Training and Finance		X	X	X	X	X
Establish system testing, security and performance standards		X				
Monitoring equipment system (sensors) installed and upgraded, in defined phases, for comprehensive coverage in CA		X	X	X	X	
Certify that system meets security protocols			X			
Certify that system meets performance standards			X			
End-users engaged to develop automated response actions		X				
End-users engaged in testing to initiate automated response actions			X			
Limited release of public alerts				X		
End-users engaged in response actions				X	X	X
Full public alerts operational					X	X
Initiate and develop public education and training program		X	X	X		
Delivery of public education				X		

and training commensurate with limited release of public alerts						
Public education and training campaign fully operational and continuing					X	X
Initiate and develop financing structure		X	X	X		
Implement financing structure for ongoing EEW sustainment				X	X	X

F. Analysis of All Feasible Alternatives

Alternative 1: Cal OES requests 4.0 permanent positions and $10 million General Fund state operations as an initial investment to build out and operate the California Earthquake Early Warning System and Program.

PROS:

- Cal OES will be able to meet its directive to implement the system in California.
- Maximizes the use of current system and resources.
- Implements the program while building financial support and sustainment structure.

CONS:

- Increase to General Fund obligations.
- Increase to state workforce.

Alternative 2: Contract out all aspects of Earthquake Early Warning development and operations.

PRO: Eliminates need for additional positions.

CONS:

- Creates a higher level burden on General Fund.
- Increased costs related to ongoing contracted services.
- Lack of stability and institutional knowledge/commitment to assure this necessary public service is maintained in future years.
- Does not fully leverage existing CISN network infrastructure (people and equipment).
- Inconsistent with existing state law requiring the use of state employees.

Alternative 3: Rely solely on non-General Fund sources to implement and operate the system*

PRO: No General Fund impact

CON: Could signal to private investors a lack of state government's commitment to the system and deter investment.

*It should be noted that this proposal includes an initial infusion of General Funds to get the system operational; non-General Fund sources must be used in future years.

G. Implementation Plan

An Implementation Framework has been developed for California which details requirements necessary to build out and operate the System and Program. This was completed by the California Earthquake Early Warning Steering Committee, a multi-agency partnership of key stakeholders involved in the System and Program development. The Framework encompasses the United States Geological Survey's (USGS) Earthquake Early Warning Technical Implementation Plan. This ensures that the State of California and USGS—the federal agency directed to implement system in the West Coast—have compatible goals that can be accomplished in a unified manner.

Components include:

- Augmentation of existing sensors and installation of new ones.
- Construction, upgrading and testing of central processing and notification centers.
- Establishment of warning notification distribution paths to the public.
- Automation of systems that will respond to early warnings, in areas such as:
- Financial Sector
- Electric, Gas and Water Utilities
- Telecommunications
- Public Safety (Fire, Law Enforcement, EMS)
- Hospital / Medical Services
- Schools
- Transportation (including trains)
- Industrial / Commercial entities
- Ports
- Information Technology
- Parallel with the technical implementation effort, public education and user training will be required to ensure safe operation and human reactions when a warning is issued.
- A financial strategy will be needed to determine fair and equitable distribution of future system costs, as well as funding mechanisms.
- Development and adoption of technical and program standards, research into new technologies, testing, reliability assurances and other continuous improvement.

H. Supplemental Information

Funding for equipment and personnel to build out and operate the California Earthquake Early Warning System network will be distributed via Interagency Agreement or contract to each respective participating agency in accordance with the formula used for CISN operations. Agencies receiving funds for California Earthquake Early Warning System network operations under this proposal will be responsible for identification and approval of additional staffing they may need to fulfill their responsibilities.

A portion of the funding for Capitol Costs and education and training costs are expected to be contributed by the federal government via the USGS. As those amounts are determined, the state contribution toward those components will be adjusted as necessary.

The financial and investment strategy and public education/training initiatives will be addressed or supported via contracted services. This will provide for optimum expertise and objectivity in these specific functional areas, as well as for efficiency—to allow simultaneous operations as staff resources are initially dedicated to the technical and governance components of the system and program.

Please see attached Implementation Framework package.

I. Recommendation

Approve Alternative 1 requesting 4.0 permanent positions and $10 million General Fund state operations for capitol and initial operating costs for California's Earthquake Early Warning program.

0690-401-BCP-BR-2016-MR

	CY	BY	BY+1	BY+2	BY+3	BY+4
Positions						
Permanent	0.0	4.0	0.0	0.0	0.0	0.0
Temporary	0.0	0.0	0.0	0.0	0.0	0.0
Exempt	0.0	0.0	0.0	0.0	0.0	0.0
Board	0.0	0.0	0.0	0.0	0.0	0.0
Total Positions	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**
Salaries and Wages						
Earnings - Permanent	0	293,000	0	0	0	0
Earnings - Temporary	0	0	0	0	0	0
Earnings - Statutory/Exempt	0	0	0	0	0	0
Overtime, Holiday, Other	0	0	0	0	0	0
Total Salaries and Wages	**$0**	**$293,000**	**$0**	**$0**	**$0**	**$0**
Staff Benefits						
Dental Insurance	0	3,000	0	0	0	0
Disability Leave	0	0	0	0	0	0
Health Insurance	0	25,000	0	0	0	0
Life Insurance	0	0	0	0	0	0
Medicare Taxation	0	4,000	0	0	0	0
OASDI	0	18,000	0	0	0	0
Retirement	0	74,000	0	0	0	0
Unemployment Insurance	0	0	0	0	0	0
Vision Care	0	0	0	0	0	0
Workers Compensation	0	0	0	0	0	0
Staff Benefits - Other	0	16,000	0	0	0	0
Total Staff Benefits	**0**	**140,000**	**0**	**0**	**0**	**0**
Total Personal Services	**$0**	**$433,000**	**$0**	**$0**	**$0**	**$0**
Operating Expenses and Equipment						
General Expense	0	20,000	0	0	0	0
Printing	0	2,000	0	0	0	0
Communications	0	8,000	0	0	0	0
Postage	0	2,000	0	0	0	0
Insurance	0	0	0	0	0	0
Travel	0	85,000	0	0	0	0
Training	0	12,000	0	0	0	0
Facilities Operations	0	0	0	0	0	0
Utilities	0	0	0	0	0	0
Consulting and Professional Services	0	2,391,000	0	0	0	0
Departmental Services	0	152,000	0	0	0	0
Consolidated Data Centers	0	0	0	0	0	0
Information Technology	0	12,000	0	0	0	0
Central Administrative Services	0	0	0	0	0	0
Office Equipment	0	6,875,000	0	0	0	0
Other	0	8,000	0	0	0	0
Unclassified/Special Adjustment	0	0	0	0	0	0
Total Operating Expenses and Equipment	**$0**	**$9,567,000**	**$0**	**$0**	**$0**	**$0**
Total Budget Request	**$0**	**$10,000,000**	**$0**	**$0**	**$0**	**$0**
Fund Source - State Operations						
General Fund	0	10,000,000	0	0	0	0
Federal Funds	0	0	0	0	0	0
Other/Special Funds	0	0	0	0	0	0
Total State Operations Expenditures	**$0**	**$10,000,000**	**$0**	**$0**	**$0**	**$0**
Fund Source - Local Assistance						
General Fund	0	0	0	0	0	0
Federal Funds	0	0	0	0	0	0
Other/Special Funds	0	0	0	0	0	0
Total Local Assistance Expenditures	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

WORKLOAD MEASURES

California Earthquake Early Warning System

Research Program Specialist II

DESCRIPTION	Quantitative Measurements Task Summary	Annual Increment	Hours (p/measurement)	Total Hours (measurement X hrs)
Research Participation Participate in, and as necessary take responsibility for, research applications for the fields of seismology, earthquake engineering, and hazards-related science related to Earthquake Early Warning or social science related to Earthquake Early Warning adoption.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Perform original research to investigate issues or gaps related to EEW.	24	10	240
	Field reconnaissance to investigate EEW system structure or work with community groups toward statewide adoption.	12	40	480
	Focused interviews or survey research to identify and assess the needs of user groups and assess ongoing impact of EEW in CA.	8	40	320
	Design pilot projects with user organizations to test new EEW applications.	4	160	640
			Total Unmet Needs	**1,680**
Research Applications Serve as a subject matter expert for Cal OES on EEW operations, education, and outreach program functions.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Prepare reports of technical findings for policy makers using non-scientific nomenclature.	4	80	320
	Research and present findings to stakeholder groups on application of EEW.	4	40	160
	Establish and maintain operational and educational partnerships on application of EEW.	12	30	360
			Total Unmet Needs	**840**

DESCRIPTION	Quantitative Measurements Task Summary	Annual Increment	Hours (p/measurement)	Total Hours (measurement X hrs)
Project Management Manage the workload of a subcommittee related to operational or educational program function.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Manage operational and educational subcommittee work and ensure timeliness.	6	60	360
	Research and present findings at EEW Advisory Board meetings.	4	80	320
	Create annual revisions and quarterly reports to contracts related to operational and educational program functions	8	20	160
			Total Unmet Needs	**840**
Additional Duties Participate in Earthquake Duty Officer Program, incorporating EEW best practices into operations.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Serve as Earthquake Program Duty Officer	20	10	200
			Total Unmet Needs	**200**

Total Current Hours	**0**	**Total PY**	**0.00**
Total Unmet Hours	**3,560**	**Total PY**	**2.00**

WORKLOAD MEASURES

California Earthquake Early Warning System

Associate Governmental Program Analyst

DESCRIPTION	Quantitative Measurements			
	Task Summary	Annual Increment	Hours (p/measurement)	Total Hours (measurement X hrs)
Research Coordination/Project Management Serves as lead administrative coordinator for the Research and Development program function.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Monitor, analyze and request work products from participating agencies, including but not limited to the Seismic Safety Commission, University of California, California State University, and other scientific and academic institutions inside and outside of California.	24	20	480
	Work with participating institutions to ensure efficient and effective delivery of research projects to be presented at EEW Advisory Board meetings.	4	80	320
	Manage operational and educational subcommittee work and ensure timeliness	6	65	390
			Total Unmet Needs	**1,190**

DESCRIPTION	Quantitative Measurements			
	Task Summary	Annual Increment	Hours (p/measurement)	Total Hours (measurement X hrs)
California EEW Program Support Assist the Program Manager with reporting needs established by the Advisory Board.	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Identify research gaps, develop and track the program's strategic plan and performance measures, and organize information to be presented to Advisory Board members.	4	80	320
	Coordinate with the Finance-Administration Division to ensure that all contracts established by the EEW program comply with state rules.	20	15	300
			Total Unmet Needs	**620**

Total Current Hours	**0**	**Total PY**	**0.00**
Total Unmet Hours	**1,810**	**Total PY**	**1.02**

WORKLOAD MEASURES

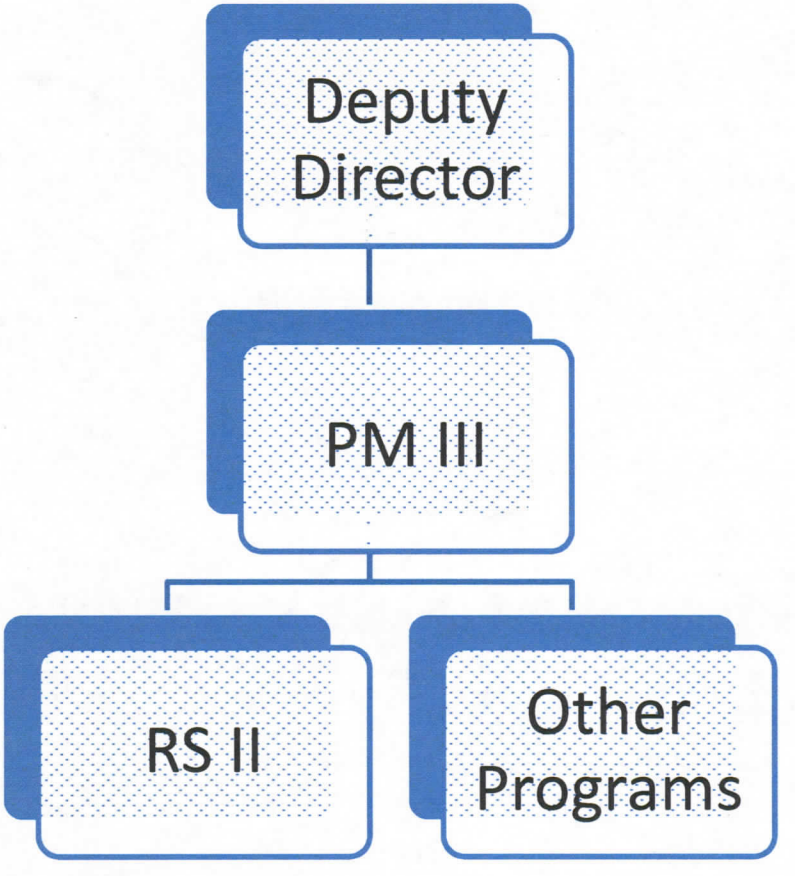
California Earthquake Early Warning System

Program Manager II

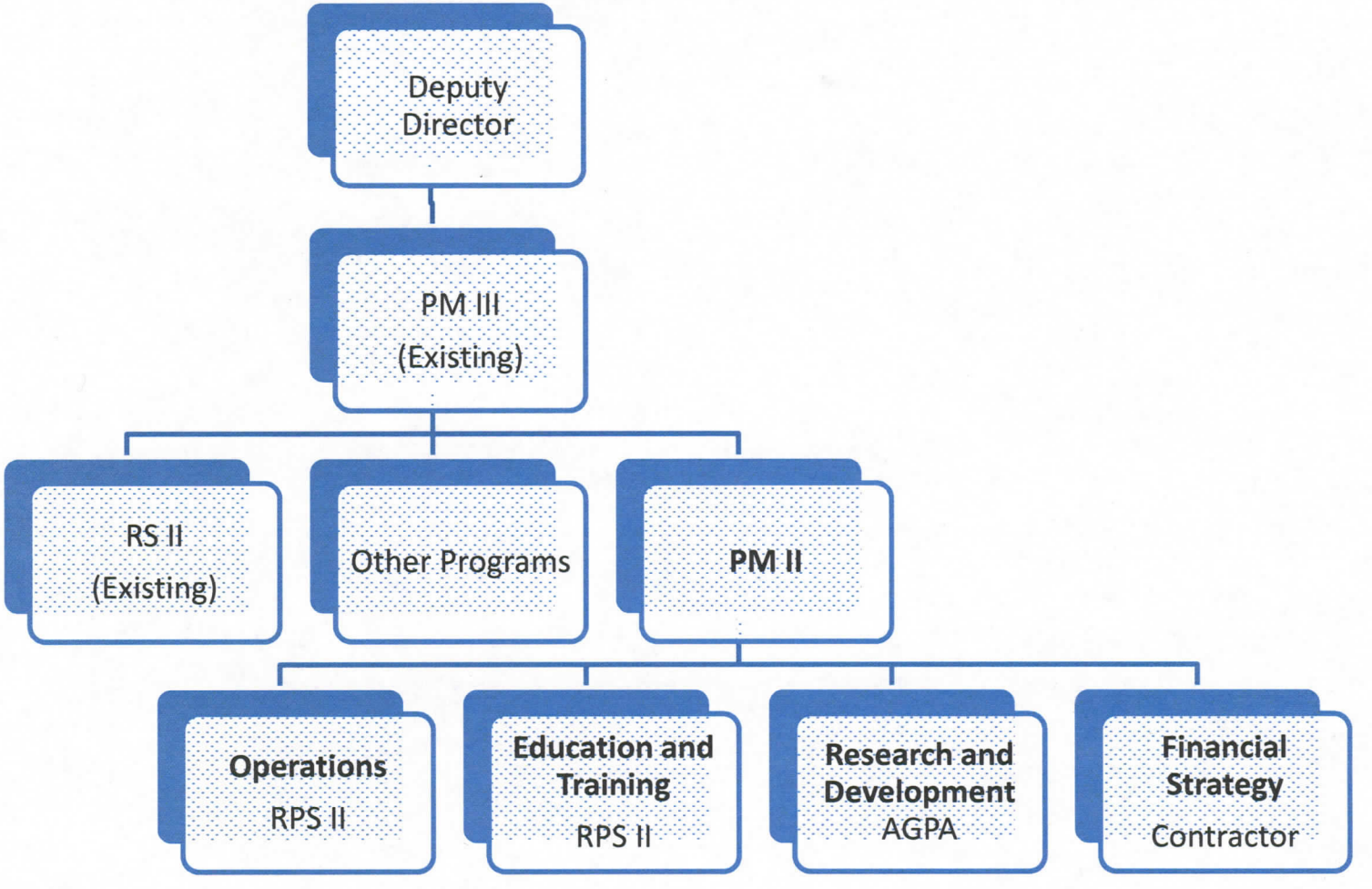
DESCRIPTION	Quantitative Measurements Task Summary	Annual Increment	Hours (p/measurement)	Total Hours (measurement X hrs)
Staff Supervision and Program Oversight	**Current Activities**			
	No current activities.			0
				0
			Total Current	**0**
	Unmet Needs			
	Provide overall management and leadership for the EEW Program Staff. Develops and implements a broad range of tasks that are complex, sensitive and diverse in nature. Oversee all aspects of Branch staff training and development, work allocation, performance measures, budget and financial management. Directly reports to and provides regular updates to the Branch Chief of the Earthquake and Tsunami Program. Represents Executive Management at key meetings as needed.	12	72	864
	Directly supervises two Research Program Specialist IIs, one AGPA, and one SSA. Oversee their staff in developing work schedules, assignments, resource allocation. Monitors program deadlines and reviews final products, including contracts administered by the program. Identifies program issues/problems and directs corrective actions.	12	40	480
	Serves as the Executive Officer for the EEW Advisory Board. Performs sensitive communication with state government appointed officials. Ensures that staff products are complete for Advisory Board meetings and that subcommittee meetings are meeting programmatic goals.	4	108	432
			Total Unmet Needs	**1,776**

Total Current Hours	**0**	**Total PY**	**0.00**
Total Unmet Hours	**1,776**	**Total PY**	**1.00**

Current



Proposed


Deputy Director
PM III (Existing)
RS II (Existing)
Other Programs
PM II
Operations RPS II
Education and Training RPS II
Research and Development AGPA
Financial Strategy Contractor

CALIFORNIA EARTHQUAKE EARLY WARNING SYSTEM

Project

IMPLEMENTATION FRAMEWORK

Contributors:

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TABLE OF CONTENTS

CEEWS
IMPLEMENTATION FRAMEWORK

I. Purpose

This Implementation Framework describes how a California Earthquake Early Warning System (CEEWS) will be rolled-out for public use. The system will build upon the successes of the California Integrated Seismic Network (CISN) as well as the ShakeAlert demonstration and prototype systems and will offer a critical time window to implement life safety responses and trigger automated mitigation measures in many institutional sectors. The plan provides a flexible framework of information about the system description, governance structure outlining roles and responsibilities of public and private sector entities and the implementation strategy. This plan can be used as a foundation for developing agency-specific work plans.

II. Scope

The Implementation Framework will describe the components of the CEEWS including field sensors to measure ground motion, improved field telemetry, construction of processing centers, establishment of public notification paths, and efforts to raise awareness of the EEW system. The plan will outline the need for a governance board that has authority to administer funding, contracts and agreements, and provide program oversight. And it will describe the implementation strategy for system deployment and education and outreach program development. The plan outlines an initial five-year implementation schedule that provides a broad framework for the responsible parties. The schedule is will require annual evaluation to address adjustments in priorities and available funding.

III. Authorities

Government Code Section 8585 charges the California Governor's Office of Emergency Services (Cal OES) with the responsibility for the state's emergency and disaster response services for natural, technological, or manmade disasters and emergencies, including responsibility for activities necessary to prevent, respond to, recover from, and mitigate the effects of emergencies and disasters to people and property.

Government Code Section 8587.8 states that the Cal OES will, in collaboration with the California Institute of Technology (Caltech), the California Geological Survey (CGS), the University of California, the United States Geological Survey (USGS), the Alfred E. Alquist Seismic Safety Commission (CSSC), and other stakeholders, develop a comprehensive statewide earthquake early warning system in California through a public private partnership.

IV. Background

Advances in scientific understanding of earthquakes and technological developments have resulted in the capacity to rapidly analyze earthquakes, small and large and provide a suite of products that are vital to emergency management especially in situational assessment and awareness early in an earthquake emergency. One such advancement is the capability to provide early warning of an earthquake a few seconds - to tens of seconds - after the nucleation of an earthquake and prior to the actual arrival of destructive ground motions from a large potentially damaging seismic event.

At present, the California Integrated Seismic Network (CISN) provides seismic information products that include time, location and magnitude of all earthquakes in California in a time frame of 30 – 90 seconds. Ground motion parameters are automatically analyzed to produce a ground shaking intensity map (ShakeMap) within 5-8 minutes after the occurrence of an earthquake. ShakeMap is also used by the Prompt Assessment of Global Earthquakes for Response (PAGER) to rapidly estimate fatalities and potential economic disruption.

In 2006, scientists and engineers at the California Institute of Technology (Caltech), UC Berkeley, the Swiss Federal Institute of Technology (ETH), and the University of Southern California (USC) started to develop and implement a prototype earthquake early warning (EEW) system for California, called CISN ShakeAlert. The project is funded through the USGS; the Gordon and Betty Moore Foundation also contributed significantly to the system's development. ShakeAlert makes use of the existing CISN infrastructure.

In 2013, Cal OES convened a working group comprised of public and private sector stakeholders to pursue development and implementation of an earthquake early warning system in California. During this same period, Senate Bill 135 was passed and signed into law as California Government Code 8587.8 mandating that an earthquake early warning system be implemented in the state. Cal OES, in collaboration with several institutional stakeholders, public agencies and private sector representatives began formally to initiate the planning process. This Implementation Framework is the culmination of that effort.

V. Objectives

The following objectives outline the milestones for the Implementation Framework:

A. **Strategy:** Pursue a deliberate, incremental roll-out strategy.

B. **Value:** Demonstrate the practical value of earthquake early warning by implementing practical applications as soon as they can be supported by the system technology as it develops.

C. **Technology:** Leverage evolving technology and communications pathways to enhance early warning effectiveness.

D. **Progression:** Demonstrate current capabilities and show progress as the system evolves while continuing to make the case that more development is required.

E. **Education:** Educate stakeholders and the public about CEEWS/ShakeAlert and foster realistic expectations.

F. **Application:** Create opportunities for both public and private sector partners to develop practical applications of the ShakeAlert data streams using multiple technologies in diverse sectors.

G. **Early Adopters:** Define performance parameters for early adopters.

H. **Refinement:** Create opportunities for testing and refinement of training and education strategies.

I. **Synchronization:** Keep the practical applications in synch with the capabilities of the CEEWS/ShakeAlert as it develops.

J. **Paces of Deployment:** Coordinate roll-out with the continuing development of all components of the whole system so as to not outpace the system's capabilities or capacity to support users.

K. **System Adoption:** Promote widespread adoption of CEEWS/ShakeAlert products in deploying automatic protective actions to the public.

L. **Cascading Roll-Out:** Conduct roll-out concurrently with ongoing development of the CEEWS/ShakeAlert system which will evolve through the phases listed below as it continues to develop.

M. **System Operation:** Provide availability of alerts and data streams for practical applications in those areas with sufficient station density as defined by CISN standards.

N. **Evaluation:** Provide for system monitoring and continuous improvement.

VI. System Description

The system will require key elements for successful implementation. Additional and upgraded field sensors will be required to measure ground motion. Telemetry used to convey data from field sensors to central processers will need to be improved. Central processing centers will need to be built or upgraded to manage the new data streams received from the field sensors. Public notification paths will need to be established via internet, public alerting systems, wireless telecommunications devices and other proprietary systems. It will also be important to raise the awareness of the earthquake early warning system as part of existing earthquake preparedness campaigns. Each element will require formative and summative evaluation to determine successful operation and where improvements are needed, all of which will lead to meeting the objective of continuous improvement.

A. Field Sensors to Measure Ground Motion

Measuring ground motion and translating the data for early warning usage will require the combination of software and hardware in the form of computer algorithms and well-placed, specialized, redundant and diverse seismic sensors.

1. **Algorithm Implementation**: In order to generate an earthquake early warning, the system will utilize computer algorithms that analyze real-time measurements of ground motion (acceleration, velocity and displacement) from both seismic and GPS instruments. The algorithms will allow the system to rapidly detect and characterize earthquakes. All data streams used by the system must meet standards adopted by the CISN.

2. **Enhanced Sensor Network**: the system will require a designed density of seismic sensors, with additional and upgraded seismic stations where necessary for density completeness and the employment of real-time GPS capabilities.

    a. Density – the optimum sensor spacing for network earthquake early warning is about 10km in urban areas and about 20km around active faults. When possible sensors should be placed within 5km of active faults but not directly in the active zone.

    b. Existing CISN stations – Approximately 469 EEW-capable stations are installed today, however, some, especially in northern California, have data latencies that could be reduced if they were upgraded. Specific tasks will be to repurpose and update as appropriate some seismic sensors

operated by the California Geological Survey to help meet this need.

c. Additional Stations Needed – 646 additional stations are needed to achieve the target station density. About 35 existing strong motion stations can be connected to the system by installing real-time telemetry without any addition equipment needed. The balance will be either new stations or older stations that will require upgraded equipment. Exhibit 1 summarizes the current stations, stations and equipment to be upgraded and additional stations that will be required.

d. Locations and Priority – the locations and priority of new and upgraded stations should take into account the most current scientific information including the CGS Fault Activity Map, the SCEC Community Fault Model, the third Uniform California Earthquake Rupture Forecast seismic hazard map (UCERF-3) and population distribution maps based on the latest census data.

e. Real-time GPS – the optimal density and location of GPS receivers is not yet determined; therefore, additional research into this question will be encouraged.

Exhibit 1: Seismic Stations (CGS, UC Berkeley, Caltech, USGS)

Stations currently contributing to EEW (both broadband and strong motion)	**469**
Station to be upgraded or added for EEW	
Broadband/strong motion, new (UC Berkeley, Caltech, USGS)	185
Broadband/strong motion, upgrade (UC Berkeley, Caltech, USGS)	138
Strong motion only, new (CGS, Caltech, USGS)	131
Strong motion only, upgrade (CGS, Caltech, USGS)	157
Strong motion only, add telemetry (CGS, USGS)	35
Total stations to be upgraded or added for EEW	**646**
Total of current and planned new and upgraded stations	**1115**

3. **Achieving the Desired Station Density**: the required station density can be achieved using several strategies in concert.

   a. Add Data Telemetry – about 35 existing stations operated by California Strong Motion Instrumentation Program (CSMIP) and the USGS National Strong Motion Project (NSMP) can contribute to the system with the addition of real-time data telemetry.

   b. Upgrade CISN Stations – Older CISN stations that are not currently suitable for earthquake early warning will be upgraded to contribute. These are Advanced National Seismic System (ANSS) Class-A stations that include both broadband and strong motion sensors. An additional 157 existing stations with only strong motion sensors (ANSS Class-B) could also be upgraded.

   c. A detailed plan for upgrading and telemetering these existing stations is being developed and carried out. These stations are operated by current CISN core members, which include the California Strong Motion Instrumentation Program (CSMIP), Northern California Strong Motion Program at U. C. Berkeley (NSMP), United States Geological Survey (USGS), and the California Institute of Technology (Caltech) (Exhibit 1).

   d. Install new CISN sensors —In addition to upgraded stations, new stations will need to be added to CISN to fill coverage

gaps, especially along active faults zones and in populated areas. Plans call for adding 185 new Class-A stations and 131 Class-B stations (Exhibit 1)

e. Installation at partner locations – When possible new CISN sensors should be installed at partner facilities to reduce permitting and lease costs, speed the permitting process, and provide the partner with direct ground motion measurements at their site. This is done now by partners like Southern California Edison, AT&T, Southern California Gas Company and others.

f. Encourage partners to install sensors — CISN will continue to encourage organizations with sufficient interest and resources to install EEW-capable seismic sensors that meet CISN standards and send the real-time data to the system. This is done now by partners like Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison, CalPine Company, California Department of Water Resources, several universities and others.

g. Integrate data from Class-C sensor networks — CISN should investigate the use of inexpensive MEMS (MicroElectroMechanical System) sensors that may be hosted by volunteers (e.g. Quake Catcher Network and Community Seismic Network) to augment the core network.

h. Leverage Existing State Property Capacity – Determine the availability and use of state property and microwave systems with excess capacity to support the installation of seismic sensors and telemetry.

4. **Additional EEW-Capable Instruments**: Two additional strategies are identified to enhance station density: Private sector sensor packages and sensor/receivers.

a. New sensors – Encourage and partner with the private sector to develop and market EEW-capable sensor packages that meet CISN standards. These can be purchased and installed by private partners. Additional sensors would be installed by the private sector to enhance their own operation as well as contribute data to the broader earthquake early warning system. By adopting standards established by CISN, private sector sensors can be compatible with the CISN sensors and can contribute to the

overall sensor density needed for an effective earthquake early warning system.

b. Sensor/receiver – Encourage the private sector to develop and market earthquake early warning sensor/receiver packages that would receive alerts or data streams and trigger local actions. These could include a sensor that would contribute ground motion data into the system.

5. **Coordination of Public and Private Data Streams:** Ground motion data streams will come from the core CISN network and contributing networks and sensor operators. General ground motion parameters (e.g. PGA, PGV, PGD) as well as EEW-specific parameters may be contributed from field equipment or regional hubs if the techniques and equipment to calculate them meet CISN standards.

6. **Technical Performance Standards:** Standards governing the design, operation, and performance of CEEWS are required to ensure a robust system that is optimized to meet end user requirements. As part of the Advanced National Seismic System (ANSS), CEEWS will need to conform to existing national standards for management, system performance, data quality and completeness, sharing seismic data and validation of methods for the creation and distribution of public earthquake information.

7. **System Implementation:** System implementation will be contingent upon the establishment of technical standards for ensuring reliability and accuracy of the performance of the following:

   a. Instrumentation & Input Data Formats
   b. System Security & Engineering criteria.
   c. Earthquake Early Warning Algorithms.
   d. Alert Messages & Distribution.
   e. Overall System Performance criteria.
   f. Criteria for affiliated operators.

   The standards will address the unique California fault systems, including the San Andreas System and others, both onshore and off-shore faults, and the Cascadia Subduction Zone in northern California, that impact the seismic risk to California's communities and economy.

   Scientific work will conform to the Department of the Interior Secretary's Order #3304 regarding scientific integrity. As part of the

ANSS, CEEWS will conform to national standards for management, system performance, data quality and completeness, sharing seismic data and validation of methods for the creation and distribution of public earthquake information.

8. **Equipment Maintenance and Life-Cycle**: Operations plans will include a strategy to maintain the system and replace hardware on a regular life-cycle schedule. The life-cycle will depend on the particular hardware but a turnover time of 10-years or less is probable.

B. Improvements to Field Telemetry

Field telemetry methods provide for data communications from field sensors to a data center. In order to improve current field telemetry capabilities the Implementation Framework calls for establishing redundant and diverse data paths, minimal use of public internet, use of partner communications systems, and compliance with CISN standards.

1. **Redundant Data Paths**: When funding allows, field sensors should send data to central processing locations via two independent telecommunications systems.

2. **Path Diversity**: If path redundancy is not possible the telemetry system should be designed and built using path diversity, that is, no single telemetry method should carry all data for a geographic area, rather many independent telemetry technologies and geographically independent paths should be used to minimize loss of system function due to failure of any one method.

3. **Minimal Use of Public Internet**: Reliance on the public internet must be minimized because it will probably fail or degrade during and after earthquakes. In addition to internet use, the system should leverage other pathways, such as satellite based telemetry, microwave and wireless signals when technically applicable.

4. **Use of Partner Communications**: When possible, data should be carried via partner telecommunications infrastructure to reduce costs, increase path diversity, and provide the partner with direct access to alerts. This is done now with partners like Southern California Electric Company, Coachella Valley Water District, Southern California Gas Company, the US Air Force and others.

5. **Cyber-Security**: Data communications must meet security standards set by CISN as well as California and National communications standards.

6. **Communications Standards**: Data communications must meet standards set by CISN for maximum allowable latency of data transmission and data loss.

C. Construction of Processing Centers

In order to promote data accuracy and processing reliability, the Implementation Framework calls for construction, upgrading and testing of central processing and notification centers. Costs for center construction would include building and infrastructure upgrades as well as data processing equipment.

1. **Redundant Processing Centers**: the data processing centers that produce and send alerts and data streams must be geographically separated and operationally independent. The centers will be located at the current CISN Tier-1 centers.

2. **Physical Robustness:** All components of the central infrastructure including computers, networking components, and power systems must be engineered to standards adopted by CISN to fulfill its warning functions during and after disasters, including but not limited to strong ground shaking, loss of commercial utilities, and unavailability of commercial telecommunications systems. All components should be configured for maximum reliability (e.g. redundant power supplies, RAID data storage disks).

3. **Software**: All software that is used in the system will be developed, managed, tested, and documented in compliance with standards adopted by the CISN.

4. **Physical Security**: Centers must meet physical access and security standards adopted by CISN.

5. **Cyber-Security**: Centers must meet computer and telecommunications security standards adopted by CISN.

6. **System Monitoring**: the system as a whole including critical sub-systems; will be monitored automatically 24/7 to ensure they are operating according to standards adopted by CISN. These automatic state-of-health monitors will notify operations personnel immediately when critical exceptions are detected and, if possible, take automatic remedial action. All detected exceptions will be logged.

7. **Retention of Results**: All output from the system and critical sub-systems will be archived to aid troubleshooting and evaluate performance.

8. **Testing and Certification**: A testing and evaluation environment should be established that simulates but is independent of the production environment.

   a. Test environment - Testing and evaluation of new code, system upgrades, and configuration changes must pass test and certification standards established by CISN before being used to the production environment. Unit test and whole-system tests should be supported.

   b. Test data interface – the test environment should allow the system and sub-systems to be tested using both real-time, live data streams and pseudo-real-time playback of historic and simulated datasets from an archive.

   c. Test datasets – test datasets should be created, organized and archived for use in the test environment and for the use of developers. These should include both real and synthetic ground motion data. The datasets should include a broad range of ground motions and events that represent both normal and anomalous examples for the purpose of rigorously testing system components.

   d. Test journaling – the output and results of test runs must be organized and saved for evaluation, troubleshooting and to document the testing and certification process.

D. Establishment of Public Notification Paths

Implementation of an earthquake early warning system will require establishment of warning notification distribution paths to the public. While public alert and warning systems are already in place for many hazards, earthquake early warning will require additional automation of existing systems in order to be effective.

1. **Alert Logic**: A module will be developed, tested, and implemented that executes decision logic on the system's output data feed and decides if an alert should be sent. The logic will be configurable and will apply threshold criteria based on the location, time, likelihood, number of reporting algorithms, and other parameters to make the send/don't send decision.

2. **Common Alert Protocol (CAP):** This plan calls for the development, testing and implementation of a module that composes alert messages in CAP format and sends them to CAP-enabled alert consumers and redistributors (e.g. FEMA Integrated Public Alert & Warning System (IPAWS), Federation of Internet Alerts (FIA), Nixle, Google Crisis Response, and other vendor-based notification systems). The module will be configurable and will apply threshold criteria to decide in which cases and to which geographic areas an alert should be sent. The final configuration of alert behavior will be set using CISN standards.

3. **Other Protocols and Formats**: Other data stream and alert formats and delivery protocols may be supported if justified by demand.

4. **Public-Facing Servers:** Redundant, geographically diverse, synchronized servers will provide both data streams and alerts to end users, and public and private value-added partners. This may be provided via cloud services.

5. **Private Sector Implementation:** Private partners should be assisted in creating additional distribution mechanisms and applications for the alerts and data streams that tie into the CISN system.

6. **Development and Test Servers**: Alerts servers must be implemented to provide test data streams and alerts to end users and value-added partners on demand, enabling them to test applications they are developing.

7. **Developer Aids**: Documentation, APIs, examples, and libraries should be provided to facilitate such development.

E. Raising Awareness of the Earthquake Early Warning System

Parallel with the technical implementation effort, public education and user training will be required to ensure safe operation and human reactions when a warning is to be issued. An essential element of the Implementation Framework will be to integrate earthquake early warning education with general earthquake preparedness efforts.

Extensive outreach and education of both public and institutional users will be needed to insure that earthquake early warning has the maximum beneficial effect. All users must therefore be educated as to what actions are effective to take upon receiving a warning, and the limitations and reliability of the warning information. Partnerships with appropriate

agencies (e.g., FEMA, CalOES, communications specialists, and specific user groups such as transportation, utilities, and hospitals) will be needed to ensure that this education occurs.

F. Incremental Performance Improvements

Each system element, from field sensors, to telemetry, processing centers, notification paths, and public awareness will include a formative evaluation as each component is developed. A summative evaluation will also be performed to assess how all elements interact. Specific time increments will be established by which improvements in reliability, accuracy and timeliness of CEEWS alerts can be assessed.

G. Cost Estimate

Estimated capital, personnel and operating costs are summarized below. Capital costs include new and upgraded seismic stations, GPS equipment, telemetry, microwave nodes, overhead and public education and outreach. Annual costs include personnel and operating costs and initial and ongoing training and education.

Options, such as leasing of warning distribution systems or additional receiver units for external essential facilities (i.e. 9-1-1 centers, EOCs, fire stations, etc. are not included in the estimate.

Exhibit 2: Estimate of Capital, Personnel and Operating Costs

Capital Costs	
Seismic Stations	$13,819,800
GPS Equipment	$ 2,730,000
Telemetry (For New and Upgraded Sites)	$ 1,438,400
Telemetry (For non-Upgraded Sites)	$ 165,600
Microwave Nodes	$ 2,500,000
Overhead	$ 1,514,529
Total Capital Cost	$22,168,329
Additional Education and Outreach Cost	$ 6,000,000
Total	**$28,000,000**
Annual Personnel and Operating Expenses	
Personnel Costs	$ 7,201,000
Operating Expenses	$ 5,732,399
Total Personnel and Operating Cost	$12,933,399
Additional Education and Outreach Cost	$ 4,000,000
Total	**$17,000,000**

VII. Assumptions and Risks

A. Assessment of Project Sensitivity

1. **California Has Many Fault Zones**: Earthquake Early Warning works best when an earthquake source area is a fixed distance from a given population, as in the case of Mexico City. In such cases the time to notify the public before shaking begins can be known beforehand. However, California has hundreds of known fault zones and others yet to be identified due to infrequent large events. Some fault zones are located under populated areas limiting the time for warning.

2. **Very Large Earthquakes Will Rupture Over A Period of Minutes**: Earthquakes that are greater than a Magnitude 8.0, will rupture over a period of minutes rather than seconds. Early warning systems must send out alarms quickly, before the earthquake has fully ruptured and continue to revise estimates of the area and intensity of shaking as the rupture grows.

3. **Seismic Sensor Coverage Will Need To Be Enhanced**: California currently has many areas of limited sensor coverage. This could result in missed events when no data is received in a timely fashion. A successful system will be dependent on

enhanced coverage of seismic sensors that are reliable enough to limit any false alarms.

4. **Need for Effective Governance:** A well-defined governance structure will be needed to administer policies, funding and contracts and agreements. Multiple agencies and organizations will have their own Implementation Frameworks that will need to coordinate with this plan. Research will be needed to demonstrate the system values to key sectors. Progress on many fronts will need constant review to ensure the many facets of deployment and outreach to the public is well coordinated. The approved governance board will need to certify that each phase is ready to be rolled-out to the public and that adequate funding is being provided for continuous operation.

5. **Need for Effective Public Acceptance**: Incorrect public understanding/action could decrease acceptance of the system and even increase safety risks.

B. Implementation Impacts

1. **Public Safety Will Be Enhanced:** Based on innovation uptake and personnel action, an earthquake early warning system has the potential to save lives and reduce property damage in a major earthquake.

2. **The Public Will Be Receptive:** Earthquake early warnings will be welcomed by users who will embrace the system as a socially responsible public service.

3. **Corporate Investments Can Be Cost Effective:** Investment and participation in the California Earthquake Early Warning System can promote a safer environment by allowing for on-site notifications and automatically stopping equipment and processes before damage could occur. This will allow for additional worker safety, improved system re-starts and reduced physical damages. Hazard mitigation efforts could also result in lower insurance costs. Individual corporate efforts can also contribute to a more comprehensive robust statewide system when seismic data are shared with CISN.

C. Factors That Could Affect the Project's Success

1. **Reliability:** False alarms or no notification when an event occurs will affect public confidence in the system's reliability. Lack of reliability will result in private sector financial losses when systems

are automatically stopped due to false alarms. Underperformance in the system could also affect future program funding decisions.

2. **Funding**: Funding from local, state and federal government and private sector investors will need to be sufficient to establish and maintain a robust, timely, and reliable system that is able to minimize false alerts and missed events.

3. **Sustainment of Operations**: Funding, such as through bond funds or other consistent sources, will also need to be sustainable in the long term in order to support the system on a continuous basis. However, funding stability for ongoing operations and maintenance will be challenged during times of budgetary austerity. Bond funding will increase the annual operating costs because of interest charges.

4. **Sustainment of Education and Outreach**: Public use of early warning will require audience understanding of a new technology and complex situations, as well as the ability to take immediate and appropriate protective actions. Experience in Japan indicates that meeting the challenge of acceptance will require concentrated outreach and education, as well as the realization that education resources and initiatives will need to be well sustained over time and refreshed following earthquake events.

VIII. Implementing Agencies and their Roles and Responsibilities

Given the existing State and Federal roles and responsibilities for earthquake early warning described below, Cal OES and the USGS will have joint responsibility for the development and operation of the government-operated earthquake early warning system in California, and its release of earthquake alerts. Cal OES and the USGS should develop a Memorandum of Agreement (MOA) recognizing their respective responsibilities for public alert and warning and clearly define how these authorities will be exercised following the detection of an earthquake.

A. California Governor's Office of Emergency Services (Cal OES)

The California Governor's Office of Emergency Services (Cal OES) is the lead public safety agency for California, including alert and warning, as well as directed to lead the development of a comprehensive California Earthquake Early Warning System in accordance with Senate Bill 135. As such, Cal OES in collaboration with the Caltech, CGS, University of California, USGS, CSSC, and other stakeholders, develop a comprehensive statewide earthquake early warning system in California through a public private partnership. Cal OES also serves as the lead for the implementation and delivery of earthquake early warning outreach and education programs within the state; coordinating with USGS and other EEW states.

B. United States Geological Survey (USGS)

The Earthquake Hazards Reduction Act (P.L. 95–124) gives the USGS the Federal responsibility for providing notifications of earthquakes. Specific to EEW the most recent NEHRP authorization (P.L. 108-360), a) notes the loss-reduction value of early-warning systems (sec 7701); b) specifically calls for disseminating warnings of earthquakes (sec 7702), and c) authorizes the USGS to establish and operate the ANSS "in order to enhance earthquake research and warning capabilities" (sec 7707). A 1997 amendment directs the USGS to develop a real-time seismic warning system (sec 7704). The USGS has designated federal authority to issue earthquake early warnings – these warnings will be coordinated with Cal OES for the CEEWS operations. In addition, the USGS conducts research on earthquake early warning, new seismic instrumentation, seismic wave propagation, earthquake effects, and fault slip behavior. It is investigating new techniques to densely monitor strong ground motions in urban areas. The data collected by new types of sensors may be used to augment the existing seismic networks to aid in the study of earthquake rupture processes, block-by-block variations in ground motion, and provide useful data for earthquake early warning systems. The USGS also provides management and financial support for the ANSS and CISN is a participating regional seismic network within the ANSS.

C. California Geological Survey (CGS)

Manages the California Strong Motion Instrumentation Program (CSMIP) established in 1971 after the San Fernando earthquake. The CSMIP installs accelerometers throughout California to measure the vertical and horizontal response of buildings and soils to strong earthquake shaking. Through the CSMIP program, CGS entered into TriNet, a partnership with the California Institute of Technology and the U.S. Geological Survey. In 2001, TriNet merged with the Northern California Seismic Network

managed by the USGS and UC Berkeley to form the California Integrated Seismic Network.

D. University of California, Berkeley (UC Berkeley)

The Berkeley Seismological Lab (BSL) monitors earthquake activity in Northern California through enhanced instrumentation, improved monitoring and analysis, and expanded archives for long-term research. The BSL operates several different networks and has expanded into a broader range of geophysical monitoring. Data from these geophysical networks are useful for rapid notification of earthquakes. Together with the USGS Menlo Park, the BSL reports earthquake information within a few minutes of occurrence. The lab also acts as part of a statewide earthquake monitoring system, the California Integrated Seismic Network. The BSL is a partner with the USGS and other institutions to promote earthquake early warning capabilities through the ShakeAlert demonstration model.

E. California Institute of Technology (Caltech)

The Caltech Seismological Laboratory was established in 1921. Caltech monitors earthquake activity in Southern California as part of the Southern California Seismic Network (SCSN), a joint project of Caltech and USGS. As part of the SCSN, Caltech monitors real-time seismicity and provides earthquake information products such as rapid notifications, moment tensors, ShakeMap, and ShakeMovie. The SCSN data is archived and distributed to researchers by the Southern California Earthquake Data Center (SCEDC). Caltech is a partner with the USGS and other institutions to promote earthquake early warning capabilities through the ShakeAlert demonstration model.

F. California Seismic Safety Commission (CSSC)

The Commission was established with passage of the Seismic Safety Act in 1975 to advise the Governor, Legislature, and state and local governments on ways to reduce earthquake risk. Commission members serve on the Steering Committee for the California Earthquake Early Warning System.

G. Federal Emergency Management Agency (FEMA)

Executive Order 13407 designates FEMA to implement the policy for a public alert and warning system. FEMA and its federal partners, the Federal Communications Commission (FCC), the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS) and the DHS Science and Technology Directorate are working together to

transform the national alert and warning system to enable rapid dissemination of authenticated alert information over as many communications channels as possible. New technologies, such as earthquake early warning, fall under the FEMA policy.

H. Private Sector

Private businesses and other vendors that provide earthquake early warning services are encouraged to partner with the California Earthquake Early Warning System in order to offer products and services that add value to the overall goals of public safety and earthquake hazard mitigation. Private sector companies should meet or exceed the government standard.

IX. Governance

The California Earthquake Early Warning System (CEEWS) requires a governance structure that provides the necessary authority to establish operational policies, administer program funding and execute contracts and agreements

A. Governance Board

Cal OES is working with the California Legislature, state agencies, boards and commissions and private sector organizations to establish a unified governance structure that will direct the implementation and management of CEEWS.

B. Legal Authorities

CEEWS governance authorities should include the legal requirements for providing early warning to enhance public safety and address legal immunities and protections for the agencies and organizations that participate in governance and system operation. The authority should also address administration of program funding and user contracts and agreements.

C. Contracts and Agreements

The governance board should have the authority to develop, approve and adopt contracts and agreements needed to facilitate program operation and interagency coordination, including with the private sector.

D. Program Oversight

The governance board, in cooperation with the USGS, should be charged with the authority to administer programs for the research and development and operation of CEEWS that provide for:

1. Evaluating continuous system improvement, reliability and accuracy
2. Making a business case that outlines specific values to key sectors
3. Conducting a comprehensive cost/benefit analysis
4. Establishing an independent peer review program for CEEWS technology and operation
5. Establishing criteria for the private sector to apply for participation in the California Earthquake Early Warning System.
6. Managing the operation and maintenance of the CEEWS.

X. Coordination with Other Early Warning Initiatives

Implementation initiatives for earthquake early warning are occurring at the local, state and federal government level as well as with the private sector.

A. USGS Implementation Plan and California Implementation Framework

CalOES will coordinate with the USGS to clarify agency roles and responsibilities regarding the operation of the California Earthquake Early Warning System. The USGS has published the *Technical Implementation Plan for the ShakeAlert Production System—An Earthquake Early Warning System for the West Coast of the United States, 2014.* In order to ensure continuity between the two plans, USGS has participated with CalOES to develop the state Implementation Framework.

B. The Role of Early Warning In the California Integrated Seismic Network

In order to clarify the relationship of the governance structure outlined in this Implementation Framework, the CISN core member organizations will revise and adopt its establishing Memorandum of Agreement (MOA) to define the relationship between the current CISN organization and the establishment of a CEEWS governance board, such as the California Earthquake Safety Board.

C. Interaction with Private Sector EEW Companies or Notification Entities

Private sector initiatives are classified as proprietary early warning systems or contract users of CISN/CEEWS.

1. **Participation On CISN and CEEWS Governance**: Public and private sector representatives currently serve as part of the CISN and CEEWS governance organizations. Private sector input across a broad spectrum of stakeholder segments is essential to a relevant and reliable seismic network.

2. **Proprietary Systems**: These are systems developed, procured, implemented and operated independently of CISN and CEEWS. These systems may or may not utilize standards established for CISN and CEEWS and may or may not be compatible with the system being developed at the state or national level. Vendors of proprietary systems are urged to develop, implement and operate compatible systems where possible. Incompatible systems cannot be used for statewide public notification if they do not meet the same performance and reliability standards established by CISN.

3. **Contract Users**: These are public and private users of early warning system equipment that is developed, procured, implemented and operated in coordination with CISN / CEEWS. Contract users utilize standards for compatibility with CISN / CEEWS at the state and national level. Contract users share data with CISN / CEEWS and may receive earthquake early warnings from the system according to the contract language.

XI. System Deployment Strategy

This Implementation Framework will pursue a deliberate, incremental roll-out strategy. The CISN partner agencies will outline the geographic areas and thresholds for which alert and data streams are distributed and, through user agreements, selecting who receives streams and how they may be used.

A. Demonstrating Value and Capabilities

The CISN partner agencies and associated EEW companies, will continue their initiative to demonstrate the practical value of EEW by signing up beta-users to receive alerts from the ShakeAlert demonstration system This allows the CISN partners to demonstrate the current California Earthquake Early Warning System capabilities and show progress as the system evolves. At the same time, system developers will continue to make the case that more development is required. Additional practical applications will be implemented as soon as they can be supported by the system as it develops.

B. Providing for Outreach Opportunities

Essential to the implementation will be to educate stakeholders and the public about CEEWS/ShakeAlert and foster realistic expectations. Sponsoring agencies will create opportunities for both public and private sector partners to develop, refine and test practical applications of the CEEWS/ShakeAlert data streams using multiple technologies in diverse sectors. The goal is to promote widespread adoption of CEEWS/ShakeAlert for taking automatic protective actions and distribution to the public.

1. **Diverse Audiences:** Different users will be willing to accept the system's limitations at different phases in the development. An incremental roll-out strategy will enable users to realize the benefits of alerts as quickly as possible where and when system capabilities can meet user needs and expectations.

2. **Outreach Concurrent with System Deployment:** The roll-out of education and outreach programs will be concurrent with ongoing system development and deployment. As the system evolves alerts can be made available to a progressively larger circle of organizations and value-added redistributors. As adoption expands users will be less knowledgeable about the system and will require more education in its uses and limitations.

C. Deploying the System

Implementation Framework

The details and timeline of the roll-out strategy must be flexible so that they can be adjusted in response to varying levels and sources of funding.

1. **Venues for Distribution**: Five venues are identified for system deployment:

   a. Early adopters - selected, knowledgeable organizations and value-added redistributors.

   b. General organizations – after distribution to the early adopters, general organizations, such as government agencies, critical infrastructure, specific organizational sectors, and value-added redistributors will be next in line for a roll–out. Public and private sector organizations should include but are not limited to:

      - Financial Sector
      - Electric Utility Sector
      - Gas Utility Sector
      - Water Utility Sector
      - Telecommunications Sector
      - Public Safety Sector (Fire, Law Enforcement, EMS)
      - Hospital / Medical Service Sector
      - Education Sector
      - Transportation Sector
      - Industrial / Commercial Sector
      - Insurance Sector
      - Ports Sector
      - Internet Technology (IT) Sector

   c. Limited public venues – public venues controlled by an organization; for example, public areas like airports, malls, and entertainment and sports venues.

   d. Limited general public – release to the public in a limited geographic area to test training and education strategies, public perception, etc.

   e. General public – distribution via all available means including IPAWS / Wireless Emergency Alerts (WEA), television, radio, smartphones, social media, commercial redistributors, etc.

2. **Deployment to Early Adopters**: Organizations selected as early adopters should have the following characteristics:

a. Will implement one or more specific, internal, practical applications
b. Will be tolerant of errors (false, missed, or late alerts and incorrect intensity estimates)
c. Are in an area with sufficient station coverage (e.g. Los Angeles and Bay Area)
d. Understands the boundary between the CEEWS/ShakeAlert system and the user application.
e. Can test the application using test alerts or data streams
f. Have management commitment, personnel, and resources to implement and maintain the application.

3. **Coordinating Deployment with Capabilities:** System deployment must be coordinated with the continuing development of all components of the whole system and must not outpace the system's capabilities or capacity to support users.

4. **Deployment Criteria:** System deployment will be contingent upon the following additional criteria:

   a. Adequate seismic station density - at each step of deployment, alerts and data streams should only be made available for practical applications in those areas with sufficient station density as defined by CISN standards.

   b. Technical performance standards - the adoption of technical performance standards and the testing and certification of the system based on those standards.

   c. Outreach - the progress of public training and education programs.

   d. Governance - the status of any changes to CISN management structure and the potential need to establish new policies.

   e. Authorities - the ability of CISN to enter into user agreements for sharing of instrument data and EEW.

   f. Staffing – the addition of staff to support reliable operation of the system.

XII. Communication, Education and Outreach Strategy

Implementation Framework

Cal OES will lead the implementation of the California Earthquake Early Warning System education and outreach program in California. Cal OES will collaborate with all affected agencies to develop education and outreach materials for technical users and the public and initiate a public awareness campaign. Based on available funding the CEEWS Education and Outreach Committee will review, prioritize and take action to implement the following tasks based on annual funding allotments. Content development and program delivery at the state level will be consistent with content development at the national level.

A. Program Development

1. **Strategy**: Begin developing educational strategy and as soon as possible, with the USGS consortium, irrespective of the time of the rollout.

2. **Content**: Coordinate with the USGS and other relevant states to cooperatively develop common and consistent content EEW education and outreach programs.

3. **Terminology**: Develop standard definitions based on educational levels and languages.

4. **Use of Social Sciences;** Draw on social science, engineering and infrastructure research about risk communication in expression of definitions, materials and educational approaches.

5. **Learning Theory**: Employ learning theory and best practices in the content and design of the educational/training modules to motivate public users. The ShakeOut drill and its education materials are examples of a way to address this issue.

6. **Existing Research**: Develop CEEWS education and outreach Program following models used in existing, successful, research-based publications for earthquake preparedness programs.

7. **Educational Materials;** Develop educational media materials for CEEWS that will, at a minimum, address the following three broad subject areas: 1) What is an earthquake early warning? 2) What are the limitations of an earthquake early warning system? 3) How should those who receive EEW messages respond once the message has been received?

8. **Messaging**: Develop educational materials that address earthquake characteristics, message elements, appropriate responses and where to find more information: Training material should include the following 5 content elements: 1) Basic

characteristics of earthquakes; 2) Likely characteristics of the message; 3) Facts about differing intensity levels potential impact on life-safety hazards including various building construction types; 4)The appropriate action to take in different situations; and 5) Links to other appropriate earthquake information.

9. **Use of Examples:** Share vivid examples of success stories of EEW, featuring a broad variety of people and organizations, and distributed by many partners using social media, newsletters, websites, presentations, and other means.

10. **Social Science Research:** Pursue additional social science research to determine whether alternate self-protective actions advice is warranted for those with seconds to tens of seconds of warning.

11. **Risk Communications Research:** Pursue additional risk communications research to determine to what extent alternate self-protective actions advice for those with seconds to tens of seconds of warning can be effectively communicated, either within the short warning message time, or via education and outreach.

12. **Research Based on Audience Location:** Pursue additional risk communications research to determine the best approaches for both location-specific advice and for broadcast alert advice (received by audiences across a region). The research needs to determine: 1) how to portray shaking variation, 2) arrival times, and 3) recommended action.

13. **Sector-Specific Messaging:** Determine to what extent education and outreach programs can reasonably be customized for a various sectors. Engage representatives of each sector to refine messaging to reflect terminology, culture and particular needs and interests of each particular group.

14. **Tsunami Content:** Explore options for inclusion of Tsunami warning, awareness and education information as part of both earthquake early warning messages and earthquake early warning education.

15. **Multiple Languages:** Develop education and outreach programs for the various language communities in California.

16. **Branding:** Establish a distinctive visual and audible brand that can be associated with EEW

17. **Cost Estimate:** Estimate and document a full scope and potential cost for an EEW education and outreach program for planning purposes. This estimate should include (1) additional social science, public health and risk communications research, (2) initial program development, and (3) annual funding for ongoing education, program maintenance and update.

18. **Budget:** Cost planning for California's early warning system should include at least $6 million specifically for initial program development of statewide education and outreach.

19. **Testing:** Incorporate capabilities for warning simulations to be delivered to (1) test the technical capabilities of the system, (2) test the response of automated systems including human interactions with such systems, and (3) allow individuals, households, schools, and organizations to practice their response. Such test warnings should be able to be segmented by user type, so that technical users may receive test messages more frequently than the general public.

20. **Program Evaluation:** Establish an on-going objective method of evaluating all aspects of the EEW education and outreach program, including the actual EEW message communicated to organizations and the public.

B. Target Audiences

1. **Audiences:** Develop CEEWS Communication Strategy and Plan to include engagement of stakeholder information providers (free-choice learning environments, government agencies, elected officials, news media, museums, schools, non-profits, etc.). Involve partners as early as possible to develop and deliver consistent information in unified campaigns. Include content to be repurposed by multiple sources through existing outreach and communication channels.

2. **Audience by Location:** Develop education and outreach programs that define specific public actions based on their location.

3. **Venues:** Develop education and outreach programs that can be offered by museums, science centers, libraries, parks and recreation facilities, fire stations, churches, and other venues.

4. **Access and Functional Needs Content:** Develop messages that can be used by people with access and functional needs.

5. **Delivery**: Provide early warning delivery mechanisms to the public as soon as the technology and funding allows, accepting that education campaigns and materials may still be in progress, and that public adoption may initially be light.

6. **Timing**: Ensure that education and outreach mechanisms are in place and that delivery campaigns are ready to expand, immediately post-earthquake, to take full advantage of the public's post-event receptivity.

7. **Referent**: The education and outreach program should be tied to the delivery of alert content to leverage the heightened public interest after feeling an earthquake.

8. **Routine Application**: Recognize that education will be ongoing, and each earthquake can be an opportunity for learning and increasing adoption rates.

9. **Promotion**: Encourage users of EEW to be advocates for its use.

C. Applications for Technical Users

Technical users include early adopters of the system, including selected, knowledgeable organizations and value-added redistributors.

1. **Training Module**: Develop a technical training module for EEW that is similar to what was developed for the successful AMBER Alert training program.

2. **Technical Information**: Education and outreach designed for technical users should include an EEW public outreach component that encourages communication of an organization's technical use of EEW to customers and clients and promotes an understanding and urges the use of EEW by these customers and clients.

3. **Technical Estimates**: Training for technical users should include the estimates of magnitude and shaking intensities.

4. **Details About Uncertainties**: Training for technical users should include an explanation of the uncertainties in the estimates of magnitude and shaking intensities.

5. **Details About Shaking**: Ensure that technical users understand that their automated response choices and "shut down trigger" algorithms must consider the internal impact of shaking intensity,

the uncertainty level of magnitude and shaking, and the particular impact of false positives to their situation.

6. **Details About Resiliency:** Ensure technical users understand that the alert is not a panacea or a prediction, and should be part of a larger hazard mitigation plan which should include retrofits to ensure resiliency.

7. **Liability Considerations:** Work with technical users regarding messages to workers, vendors, etc. regarding conformity with OSHA and other regulations to address their liability considerations.

D. Applications for Private Sector Users

1. **Preparedness Programs:** Incorporate EEW education and outreach within existing preparedness programs for the private sector.

2. **Use of Approved Content:** Any private entities that create their own delivery program should be required to include approved, appropriate and standardized education and outreach.

3. **Developers and Service Providers:** for Developers of EEW devices and value-added service providers, education and outreach should orient private sector entities to the various roles private sector may play in the development, deployment and maintenance of an early warning system.

4. **Employers and System Users:** Ensure educational programs targeted at non-automated operational users provide specific advice to employers that guide augmentation of their emergency plans to incorporate warning-based actions that protect their infrastructure, process, employees and customers.

E. Collaboration with Other Disaster Preparedness Activities

1. **Education Plans:** Link EEW education with Common Core math standards and California science standards, California health education content standards, and transition/life skills for Special Education Individual Education Plans.

2. **Program Development:** Incorporate EEW education and outreach as part of school earthquake education programming and activities, including school emergency preparedness assemblies, school visits to museums and science centers, and similar efforts.

3. **Earthquake Drills**: Incorporate EEW training as part of regular school earthquake drills, especially the annual ShakeOut drill.

F. Applications for the General Public

1. **Synchronize Outreach with the System Deployment Schedule**: Public venues include general organizations, limited public venues, limited general public and general public.

2. **General Organizations**: After distribution to the early adopters, general organizations, such as government agencies and value-added redistributors will be next in line for a roll–out.

3. **Limited Public venues**: Public venues controlled by an organization; for example, public areas like airports, malls, and entertainment and sports venues.

4. **Limited general public**: Release to the public in a limited geographic area to test training and education strategies, public perception, etc.

5. **General Public**: Distribute via all available means including IPAWS/WEA, TV, Radio, smartphones, social media, commercial redistributors, etc.

6.

G. Emergency Messaging

1. **Message Content**: Public Warning messages should include four research-based elements for effective instructional crisis communication messages.: .

2. **Delivery Methods**: Deliver CEEWS alert/warnings through as broad a range of methods and distribution channels as possible.

3. **Delivery Limitations**: Recognizing existing public alert/warning methods (including IPAWS) may currently have constraints that make their use for EEW impractical or limited, coordinate with these warning providers to improve and augment these delivery methods to accommodate CEEWS messaging.

4. **Targeted Delivery**: Concentrate development efforts for Earthquake Early Warning delivery on CEEWS-specific delivery methods, given the current constraints of existing alert and warning mechanisms.

5. **Location-Specific Content**: Develop separate Public Earthquake Early Warning messages (1) those whose location can be identified and (2) those who will receive a message via general broadcast.

6. **Location-Specific Detail**: Where the receiver's location is known, describe the expected intensity level, include a map for relevance/proximity, provide a countdown to the arrival of the S-wave (timeliness), and include specific recommended action steps.

7. **Television and Radio Content**: Messages broadcast on TV or radio should be formulated to take into account that different geo-locations will receive very different levels of shaking.

8. **Smart Phone Applications**: Phone applications that deliver a warning should have embedded educational material (not needing a live network), so that they can be accessed after an earthquake when the network may be down.

9. **Awareness Versus Action**: Develop separate Public Earthquake Early Warning messages for non-damaging shaking (awareness) and strong shaking (action.)

10. **Brevity**: Constrain the key elements of CEEWS warning message content to 5 seconds or less.

11. **Public Access**: Ensure a basic method of Earthquake Early Warning delivery is available to the public with no cost, as a public good.

XIII. Tasks and Timelines

The CEEWS Implementation Framework outlines the major tasks for developing the California Earthquake Early Warning System. The CISN partner agencies, including CalOES, CGS, UC Berkeley, Caltech, USGS, California Seismic Safety Commission, and other public agencies and the private sector organizations have developed, or are developing, detailed implementation plans to meet their individual organizational priorities. Timelines for the participating agencies are based on the availability of funding.

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XV. Framework Approval

The CEEWS Implementation Framework was approved by the CEEWS Steering Committee, which consists of the CISN partner agencies and other public and private sector representatives. This framework is intended to be flexible so as to allow each agency to develop and administer detailed agency-specific work plans that meet their organizational needs.

_____ _____

Mark S. Ghilarducci Date
Director, California Governor's Office of Emergency Services
Chairman, CEEWS Steering Committee

XVI. Appendices

A. Appendix A: Acknowledgements
B. Appendix B: Acronyms
C. Appendix C: Glossary

Appendix A
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California Department of Education
California Department of Finance
California Department of Insurance / Community Programs and Policy Initiatives
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California Department of Transportation
California Department of Water Resources
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Appendix B
ACRONYMS

Acronym	Description
ADC	Analog to Digital Conversion
AFN	Access and Functional Needs
ANSS	Advanced National Seismic System
API	Application Program Interface
AQMS	ANSS Quake Monitoring System
ARRA	American Recovery and Reinvestment Act
AT&T	American Telephone and Telegraph Company
BSL	Berkeley Seismological Laboratory
Cal OES	California Office of Emergency Services
Caltech	California Institute of Technology
CAP	Common Alerting Protocol
CEA	California Earthquake Authority
CEEWS	California Earthquake Early Warning System
CEPEC	California Earthquake Prediction and Evaluation Committee
CGS	California Geological Survey
CISN	California Integrated Seismic Network
CRADA	Cooperative Research and Development Agreement
CSMIP	California Strong Motion Instrumentation Program
CSSC	California Seismic Safety Commission
CVWD	Coachella Valley Water District
DAU	Data acquisition Unit
EAS	Emergency Alert System
EEW	Earthquake Early Warning
EW	Earthquake Warning
FEMA	Federal Emergency Management Agency
FIA	Federation for Internet Alerts
FIPS	Federal Information Processing Standards
FISMA	Federal Information Security Management Act
GMDCS	Ground Motion Data Collection System
GNSS	Global Navigation and Satellite System
GPS	Global Positioning System
ID	Identity
IID	Imperial Irrigation District
IP	Intellectual Property Rights
IPAWS	Integrated Public Alert & Warning System
ISA	Internet Security Agreement
IT	Information Technology
LAN	Local Area Network
M	Magnitude (As in M7)
M&O	Maintenance and Operations
MEMS	MicroElectro Mechanical Systems
MMIS	Modified Mercalli Intensity Scale
MOA	Memorandum of Agreement

MOA	Memorandum of Agreement
ms	Millisecond
NCSS	Northern California Seismic System
NDA	Non-Disclosure Agreement
NEPA	National Environmental Policy Act
NEPEC	National Earthquake Prediction and Evaluation Committee
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NSMP	National Strong Motion Program
NTP	Network Time Protocol
O&M	Operation and Maintenance
OES	California Governor's Office of Emergency Services
OFR	Open File Report
OH	Overhead
P Wave	Primary Wave / Compressional Wave
PGA	Peak Ground Acceleration
PGE	Pacific Gas and Electric Company
PGD	Peak Ground Displacement
PGV	Peak Ground Velocity
PMC	Program Managers Committee
PY	Person Year
QA	Quality Assurance
R&D	Research and Development
RAID	Redundant Array of Independent Disks
RT	Real time
S Wave	Secondary Wave / Shear Wave / Transverse Wave
SB	Senate Bill – California – SB135
SCE	Southern California Edison Company
SCEC	Southern California Earthquake Center
SCSN	Southern California Seismic Network
SDGE	San Diego Gas and Electric Company
Sec	Second
SEED	Standard for the Exchange of Earthquake Data
SM	USGS Survey Manual
SP	Special Publication
UASI	Urban Area Security Initiative
UC	University of California
UCERF	Uniform California Earthquake Rupture Forecast
USGS	United State Geological Survey
V or VI	References Intensity V or VI – may not be clear to the reader what V or VI are.
VPN	Virtual Private Network
WAN	Wide Area Network
WEA	Wireless Emergency Alerts
XML	Extensible Markup Language

Appendix C
GLOSSARY

Accelerometer: A sensor that measures acceleration, like a speedometer measures speed. An accelerometer is often part of an accelerograph, which is an instrument that contains accelerometers and records the acceleration record. The acceleration record is called an accelerogram.

Advanced National Seismic System (ANSS); A nationwide network of ground motion sensors, both on the ground and in buildings, that provide: (1) emergency response personnel with real-time earthquake information, (2) engineers with information about building and site response, (3) scientists with high-quality data to understand earthquake processes and solid earth structure and dynamics and (4) real-time data streams for EEW. The CISN is a region of the Advanced National Seismic System.

Alert: For simple applications that can only handle a simple on/off type of alert the system will send alerts in CAP format defining areas that will meet or exceed a predetermined threshold of shaking. Users within that area can then be notified that strong shaking is coming. The threshold value will be set by the emergency management authorities. The behavior of this type of alert will be driven primarily by the limitations of alert deliver systems like IPAWS.

Alert Communication Interface: A server interface to which a user would connect to receive data or alert feeds.

Alert Communication Facility: A data center that hosts an alert communication interface.

Alert feed: An output from the CEEWS system that provides approved users with simple real-time alert messages in CAP format that describe areas that will meet or exceed a predetermined threshold of shaking.

AMBER Alert: The AMBER Alert™ Program is a voluntary partnership between law-enforcement agencies, broadcasters, transportation agencies, and the wireless industry, to activate an urgent bulletin in the most serious child-abduction cases.

Algorithm: A computer code used for Earthquake Early Warning to detect the initial P-waves from an earthquake, rapidly estimate the hazard potential, and send out an alert message.

Amplitude: The height of the crest of a seismic wave above an adjacent wave trough.

ANSS Quake Monitoring System (AQMS): A suite of software programs used by ANSS regional networks for their operations and earthquake reporting.

California Earthquake Early Warning System (CEEWS): A description of the system for the state of California. The system encompasses a system description that includes overall features and functions, public and private integration, performance according to established performance standards, and a public outreach program. It is a part of the CISN.

California Integrated Seismic Network (CISN): A partnership among federal and state, agencies, universities and private sector organizations that are involved in jointly operating California's earthquake monitoring networks. The core members of CISN are Cal OES, CGS, USGS, Caltech and UC Berkeley. The CISN is dedicated to serve the emergency response, engineering, and scientific communities. The CISN is a region of the Advanced National Seismic System.

CEEWS Applications: The application of processed data for Earthquake Early Warning. Examples include: (1) Public Alert System broadcast message redistributed to Radio, Television, EAS/IPAWS Receivers; (2) messages redistributed to smart phone applications; or (3) data redistributed to facility / equipment controller.

CEEWS Input Data: Sensor and telemetry data received from CISN partner agencies as part of the California Earthquake Early Warning System.

CEEWS Output Data: Data that has been processed from the CISN partner agencies and converted into (1) messages for use in Public Alert Systems; (2) Data sent to direct users; or (3) Data to be used by redistribution services.

CEEWS Processors: CISN computers used for processing input data.

Common Alerting Protocol (CAP): A digital format for exchanging emergency alerts that allows a consistent alert message to be disseminated simultaneously over many different communications systems.

Data Feed: An output from the CEEWS system that provides approved users with a continuously updating stream of messages in XML format containing information about the evolving earthquake including its origin time, location, magnitude, likelihood, and the extent and distribution of the fault slip. This stream can optionally include direct measurements of peak ground motions from sensors and other parameters of engineering interest. This stream can be used by sophisticated receivers to make well informed, complex decisions and formulate appropriate responses.

Data Logger: An electronic device linked to earthquake sensors and a computer processer that records seismic data over time or in relation to location.

Earthquake Early Warning (EEW): A warning of pending earthquake ground shaking before shaking arrives; an early warning system depends on a network of sensors that are appropriately spaced and in proximity to earthquake generating faults, quick and robust telecommunication from field sensors; efficient computer algorithms to quickly

estimate an earthquake's location, magnitude, and fault rupture length, and to map resulting intensity, quick and reliable mass notifications, and people educated in how to use the alerts.

Earthquake: Ground shaking caused by the sudden movement on a fault, or by volcanic or underground magmatic activity, or other sudden stress changes in the earth's structure.

Emergency Alert System (EAS): A national public warning system that requires broadcasters, satellite digital audio service and direct broadcast satellite providers, cable television systems, and wireless cable systems to provide the President with a communications capability to address the American people within 10 minutes during a national emergency. The President has sole responsibility for determining when the national-level EAS will be activated. FEMA is responsible for national-level EAS tests and exercises. EAS is also used when all other means of alerting the public are unavailable, providing an added layer of resiliency to the suite of available emergency communication tools. EAS may be used by state and local authorities, in cooperation with the broadcast community, to deliver important emergency information, such as weather information, AMBER alerts, and local incident information targeted to specific areas.

GPS Position Sensor: A sensor technology that uses Global Navigation Satellite System (GNSS) signals to determine position. Modern high-precision, high-rate sensors can detect real-time changes in position with a precision of a few millimeters up to five times per second. They also record the permanent displacement of the ground caused by an earthquake allowing modeling of the earthquake fault (Source: USGS).

Ground Motion: The movement of the earth's surface resulting from sudden stress changes or explosions affecting the earth's crust. Ground motion is produced by energy waves that are generated by the sudden slip on a fault, crustal adjustments caused by massive weight changes or fluid pressure changes or sudden pressure changes at an explosive source, and travel through the earth and along its surface.

Integrated Public Alert and Warning System (IPAWS): An internet-based capability that Federal, State, territorial, tribal, and local authorities can use to issue critical public alerts and warnings. IPAWS is a modernization and integration of the nation's existing and future alert and warning systems, technologies, and infrastructure.

Intensity: Represents the level of shaking caused by earthquake waves at a particular location; depends on magnitude + distance + local geology and varies from place to place in a single earthquake.

Magnitude: An abstract number representing the amount of energy released in an earthquake; depends on the size (surface area) of fault rupture.

Memorandum of Agreement (MOA): A cooperative agreement written between parties to cooperate on an agreed upon project or meet an agreed objective. The purpose of an MOA is to have a written understanding of the agreement between parties.

P-Wave: A seismic body wave that shakes the ground back and forth in the direction the wave is moving. Also refers to a compressional wave or primary wave.

Real-time Data Stream: A stream of real-time data contributed to the CEEWS system by partners that may include ground time-series, parameters derived from ground motion records, or event declarations including origin time, location, magnitude, rupture description. Data streams may be made available to partners according to the participation guidelines.

SB135: Senate Bill 135, codified as Government Code Section 8587.8, directs Cal OES to develop a comprehensive statewide Earthquake Early Warning system in California through a public-private partnership and identify funding sources by January 1, 2016 that do not specify the General Fund as a funding source.

Seismometer: A sensor that measures the velocity or speed of a point on the ground as it moves in response to earthquake shaking. Most velocity sensors are high precision, sensitive instruments designed to record motions from distant earthquakes rather than the strong shaking that occurs near to earthquake epicenters.

ShakeAlert: A prototype Earthquake Early Warning System currently in use for the United States West Coast; in California, detects earthquakes using the California Integrated Seismic Network (CISN), an existing network of more than 400 high-quality ground motion sensors. When fully operational, ShakeAlert will be able to distribute alerts through all available distribution channels, including FEMA's Wireless Emergency Alert system and Integrated Public Alert and Warning System, smartphone apps, social media providers, and other electronic alert technologies as they develop.

Station: A location where seismic and or GPS equipment is installed. A station may have several sensors that can contribute to EEW.

Strong Motion Sensor: A type of accelerometer that records the strong shaking of the ground and in structures during earthquakes for the engineering and scientific communities through a statewide network.

Strong Motion: Ground motion of sufficient amplitude and duration to be potentially damaging to a building or other structure.

S-Wave: A seismic body wave that shakes the ground transversely or back and forth perpendicular to the direction the wave is moving. Also refers to shear wave or secondary wave.

TriNet: a partnership formed in 1996 among the California Geological Survey, the California Institute of Technology, and the U.S. Geological Survey to modernize seismic network monitoring in southern California. In 2001, TriNet joined with the Cal OES and the Northern California Seismic Network, which is managed by USGS and UC Berkeley, to form the California Integrated Seismic Network (CISN).